MODERN MANUFACTURING TOOLS & TECHNIQUES

Lecture-1
Automation & NC System

❖ AUTOMATION

- Automation is the creation of technology and its application in order to control and monitor the production and delivery of various goods and services.
- It performs tasks that were previously performed by humans.
- Automation generally implies the integration of machines into a self-governing system.
- The term automation was introduced in the automobile industry about 1946 to describe the increased use of automatic devices and controls in mechanized production lines.
- Automated systems have become increasingly sophisticated and complex.
- Advanced systems represent a level of capability and performance that surpass in many ways the abilities of humans to accomplish the same activities.
- Automation covers applications ranging from a household thermostat controlling a boiler, to a large industrial control system with tens of thousands of input measurements and output control signals.
- Automation has been achieved by various means including mechanical, hydraulic, pneumatic, electrical, electronic devices and computers, usually in combination.

❖ NEED OF AUTOMATION

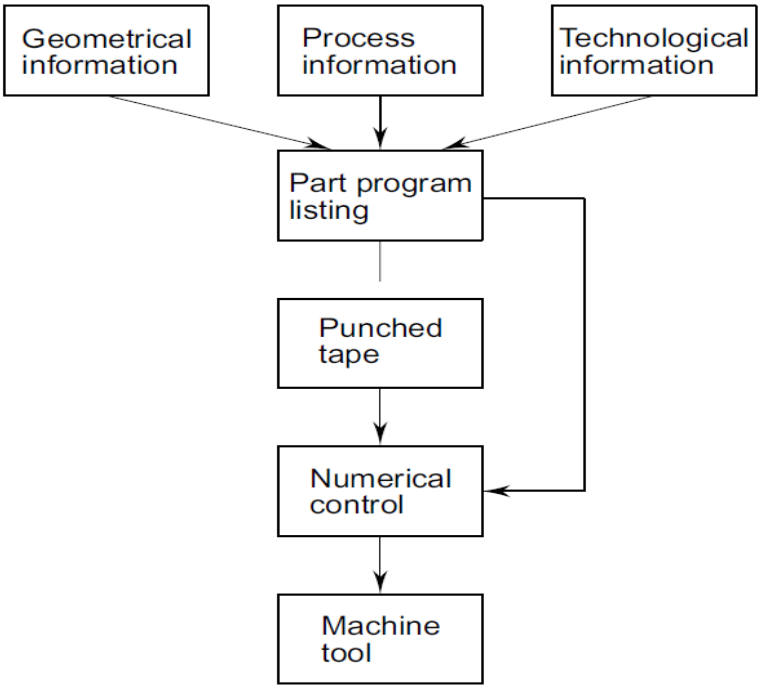
- Competition between manufacturing firms is increasingly dictated by quality, cost, variety and servicing.
- Today, the need of any business is to do things in an optimum way so that everything will be fast and quickly adaptable.
- If manufacturers don’t change themselves under such a scenario, it will create a big problem for their business.
- Manufacturing lines need to be so flexible that the product is made as per the market requirement & customers’ expectation.
- To achieve these industries needs flexible automation, where industries get the benefits of rigid automation but also be able to vary the products they can manufactured, thus bringing in flexibility.

❖ NUMERICAL CONTROL SYSTEM (NC SYSTEM)

- Numerical control (NC) is the concept which has revolutionized the manufacturing in late 1960's.
- It is a method of automation in which various functions of machine tools are controlled by letters, numbers and symbols.
- NC machine runs on a program consists of precise instructions about the methodology of manufacture as well as the movements.
- In NC machine can perform the following functions automatically:
  1. Starting and stopping of machine tool spindle.
  2. Controlling the spindle speed.
  3. Positioning the tool tip at desired locations and guiding it along desired paths by automatic control of the motion of slides.
  4. Controlling the rate of movement of the tool tip (Feed rate)
  5. Changing of tools in the spindle.

❖ WORKING PRINCIPLE OF NC MACHINE TOOL

1. The basic information part geometry, cutting process parameters followed by the cutting tools use are to be prepared in form of part program.
2. This part program is then entered into the controller of the machine, which in turn runs the machine tool to make the part.
3. The command received from the operator is communicated to the corresponding axis driving system for execution.
4. The axis motion control system operates in a feedback loop with suitable transducers such as linear scales and/or rotary encoders to get the appropriate position or velocity feedback of table and tools.
5. Most of these systems have a very high response with good resolution of the order of 1 mm (micron) or less.



❖ ADVANTAGES OF NC MACHINES

1. Parts can be produced in less time and therefore are likely to be less expensive.
2. The idle (non-cutting) time is reduced to absolute minimum.
3. Parts can be produced more accurately even for smaller batches.
4. The operator involvement in part manufacture is reduced to a minimum.
5. No operator skill is needed except in setting up of the tools and the work.
6. The need for expensive jigs and fixtures is reduced.
7. Inspection time is reduced, since all the parts in a batch would be identical.
8. The need for certain types of form tools is completely eliminated in NC machines.
9. Machining times and costs are predictable to a greater accuracy
10. Tools can be utilized at optimum feeds and speeds

❖ LIMITATIONS OF NC MACHINES

1. The cost of NC machine tool is much high compared to an equivalent conventional machine tool.
2. Skill of the people required to operate a NC machine is generally high due to complex and sophisticated technology.
3. Special training is needed for the personnel manning the NC machine tools.
4. Higher maintenance cost.
5. The requirement of a conditioned environment for operating NC technology adds further to the running costs.

Lecture-2
CNC System Components and Working

❖ COMPUTER NUMERICAL CONTROL SYSTEM [CNC]

- The next stage in the development of numerical control is control hardware (mounted on the NC machine) was converted to local computer control by software.
- In CNC (Computer Numerical Control) machines, a dedicated computer is used to perform the most of basic NC machine functions.
- CNC (Computer Numerical Control) machine is a NC machine which uses a dedicated computer as the machine control unit.
- The entire program is entered and stored in computer memory. The machining cycle for each component is controlled by the program contained in the computer memory.
- The stored part program listing can be used for future production.
- CNC is a microprocessor based control system.
- CNC accepts a set of program instructions, processes and sends output control information to a machine tool,
- CNC accepts feedback information acquired from a transducer placed on the machine tool and based on the instructions and feedback, assures that proper motion, speed and operation occur.
- Some of the important parts of CNC machines are machine structure, guide ways, feed drives, spindle and spindle bearings, measuring systems, controls, software and operator interface, gauging, tool monitoring.

❖ CLASSIFICATION OF CNC MACHINE TOOL SYSTEMS

(a) According to type of Feedback systems:

- Open loop type CNC machine.
- Closed loop type CNC machine.

(b) According to type of tool motion control:

- Finite positioning control CNC
- Continuous path control CNC

(c) According to program methods:

- Absolute Programming CNC
- Incremental Programming CNC

(d) According to type of controller:

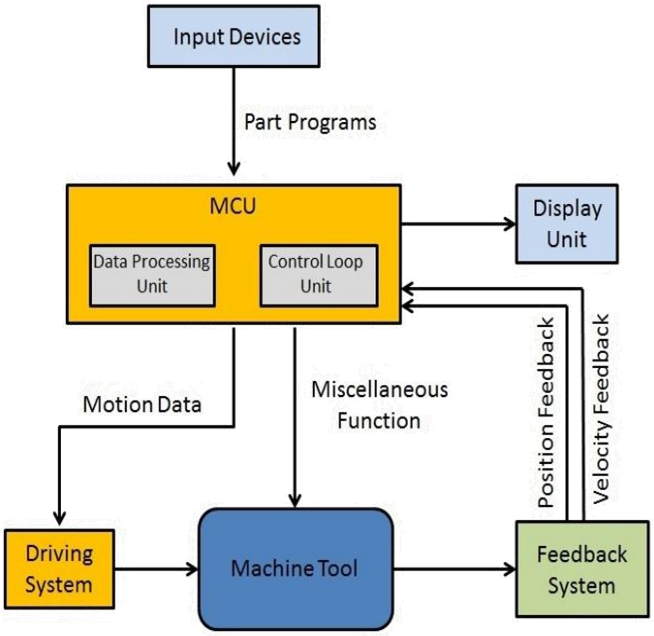
- Hybrid controller CNC systems.
- Straight controller CNC systems.

(e) According to axis & type of operations:

- CNC horizontal machining centre.
- CNC vertical machining centre.
- CNC turning centre.
- CNC milling centre.

❖ COMPONENTS OF CNC

1. **Input / Output Console.**
2. **Microprocessor Based control unit.**
3. **Memory.**
4. **Feedback unit.**
5. **Machine Tool.**
6. **Interfaces.**



- **Input / Output Console**

  It is the unit through which part program is fed to the CNC machine tool system and required output is taken out. It basically consists of monitor and Keyboard.

- **Microprocessor**

  This controller takes input from Input / Output device, Feedback from feedback unit and actuates the drives as well as the tool of the machine tool.

- **Memory**

  It consists of RAM & ROM. The RAM stores part program, while ROM stores the programs for machine control.

- **Feedback Unit**

  The feedback unit takes input from machine tool and transfers it to control unit for necessary corrections.

- **Machine Tool**

  The machine tool is consists tool room, tool holder, work holding device, power source, etc. Machine tool is operated by the control unit.

- **Interfaces**

  They are the connections between the different components of the CNC machine tool system.

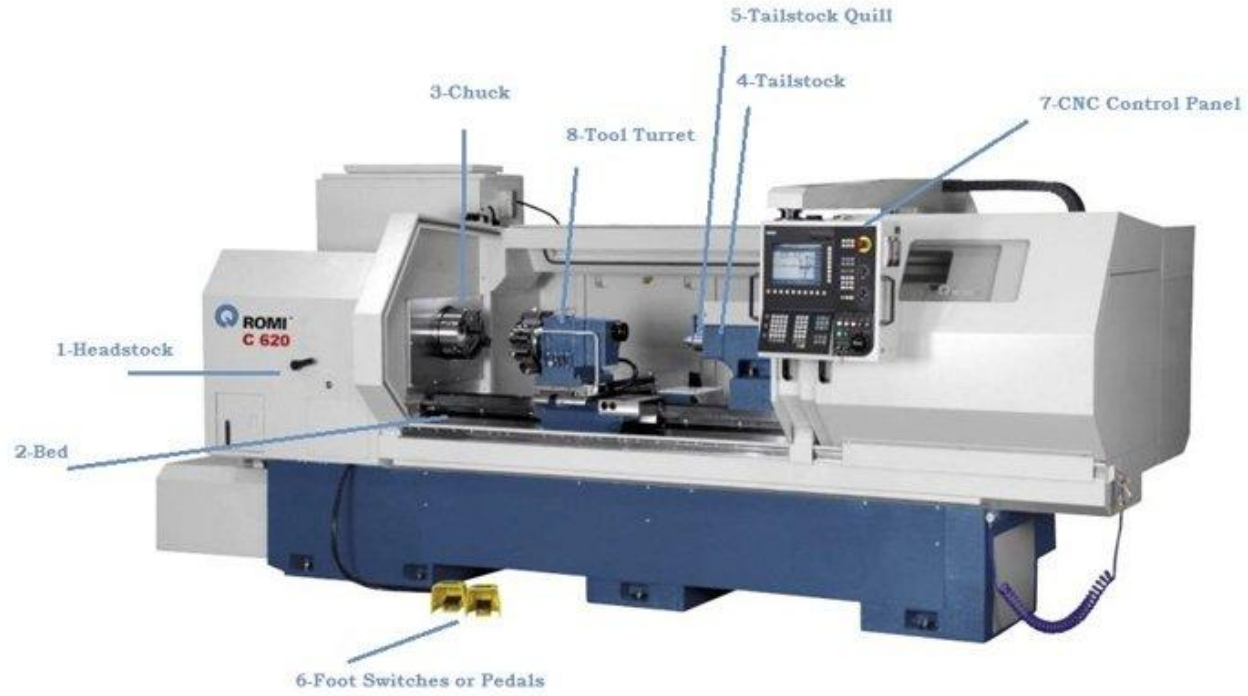
Lecture-3
CNC System Advantages and Limitations

❖ ADVANTAGES OF CNC SYSTEM

1. High Repeatability and Precision.
2. Volume of production is very high.
3. Complex contours/surfaces need to be machined, e.g. Turbines.
4. Flexibility in job change, automatic tool settings, less scrap.
5. Safer, higher productivity, better quality.
6. Less paper work, faster prototype production, reduction in lead times.
7. Easier to program.
8. Easy storage of existing programs.
9. Avoids human errors.
10. Usually generates closer tolerances than manual machines.
11. Program editing at the machine tool.
12. Control systems upgrades possible.
13. Option -resident CAM system at machine tool.
14. Tool path verification.

❖ LIMITATIONS OF CNC SYSTEM

1. Higher investment cost.
2. Higher maintenance cost.
3. Requires specialized operators.
4. Conditioned room temperature required.



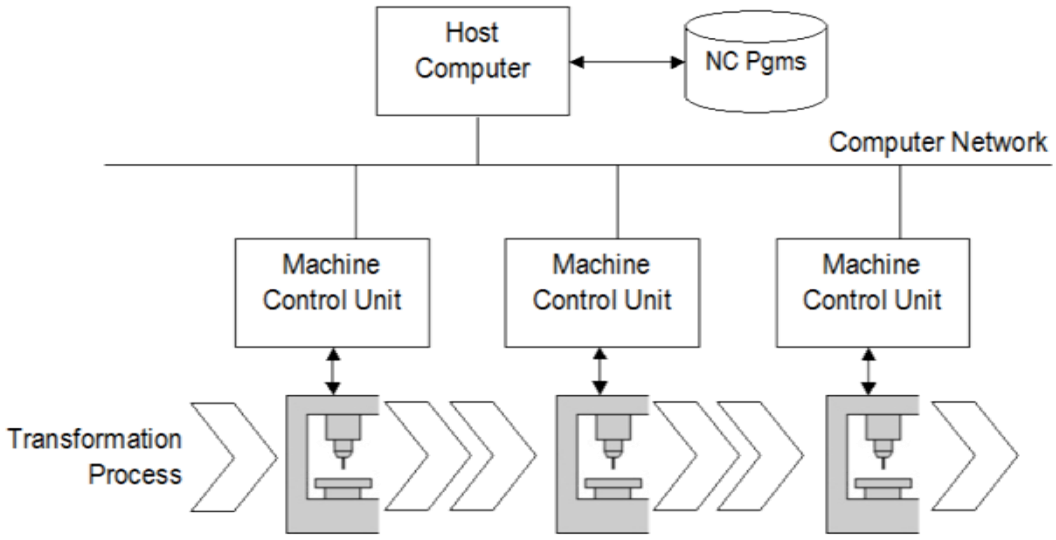
CNC Lathe Machine

CNC Milling Machine

Lecture-4
DNC System

❖ DIRECT NUMERICAL CONTROL (DNC)

- In DNC manufacturing system several NC or CNC machines are controlled remotely from a Host/Main frame computer.
- DNC is control of multiple machine tools by a single (mainframe) computer through direct connection.
- DNC is eliminating substantial hardware from the individual controller of each machine tool.



❖ CHARACTERISTICS OF DNC SYSTEM

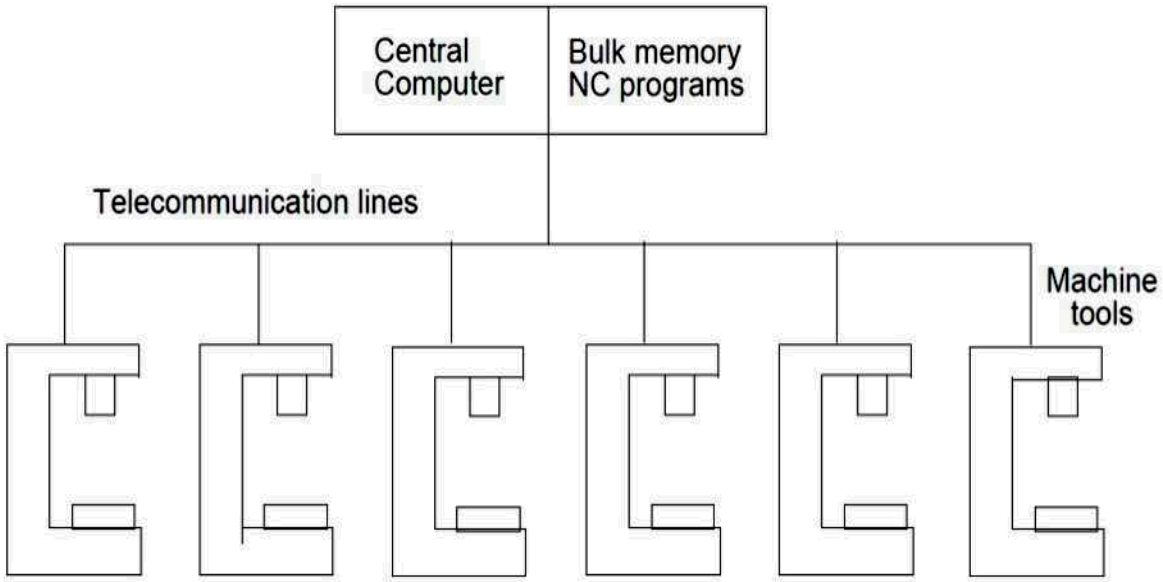
- A central computer connected to a number of machine tools and control them
- Part program of all machine tools are stored in the memory of the central computer and transmitted on direct transmission lines on demand
- Two way information flow take place in real time
- Various machine tools can communicate with the computer in real time
- Programs in full or segment can be transferred to NC machines
- Computer can be used for program editing
- No tape readers are used
- No limitation for the number or size of programs stored

❖ COMPONENTS OF DNC

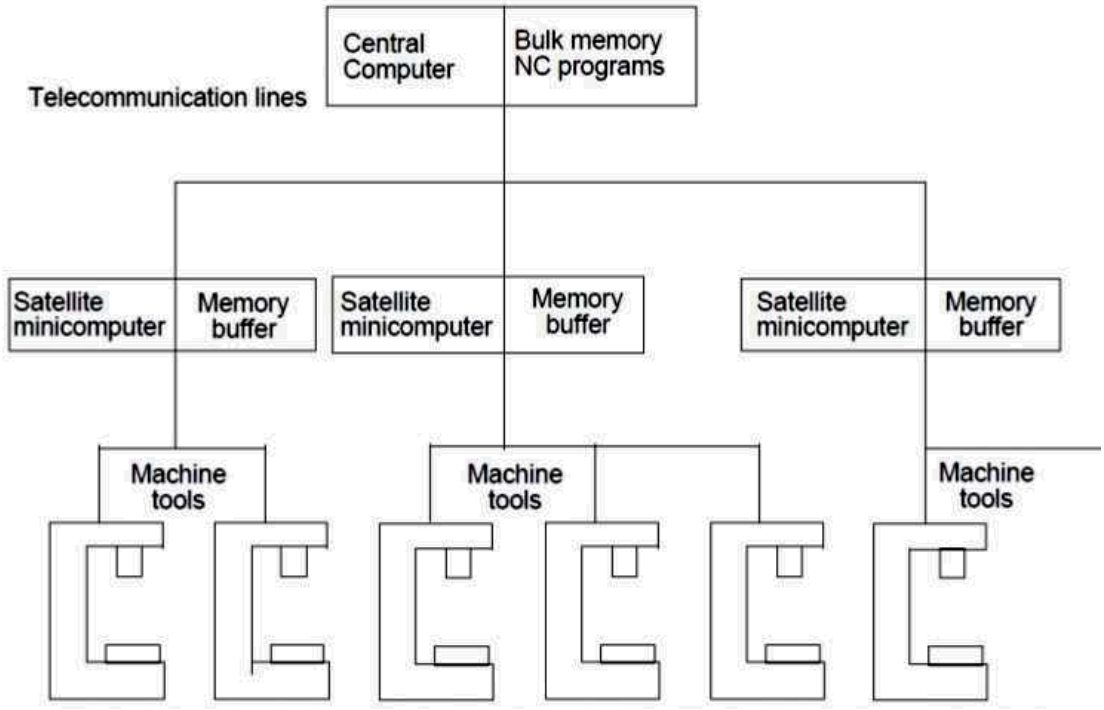
1. Central computer
2. Bulk memory which stores the NC part programs
3. Telecommunication lines
4. Machine Tools.

❖ TYPES OF DNC SYSTEM

DNC WITHOUT SATTELITE COMPUTERS



DNC WITH SATTELITE COMPUTERS



Lecture-5
Comparison between NC, CNC & DNC Machines

❖ COMPARISON BETWEEN NC, CNC & DNC

NC Machines	CNC Machines	DNC Machines
1. The part program is fed to the machine through the tapes or other such media.	**1.** In CNC machine tool system, the program is fed to the machine through the computer.	**1.** The part program is fed to the machine through the Main computer.
2. In order to modify the program, the tapes have to be changed.	**2.** The programs can be easily modified with the help of computer.	**2.** In order to modify the program, single computer is used.
3. In NC machine tool system, tape reader is a part of machine control unit.	**3.** The microprocessor or minicomputer forms the machine control unit. Does not need tape reader.	**3.** Large memory of DNC allows it to store a large amount of part program.
4. System has no memory storage and each time it is run using the tape.	**4.** It has memory storage ability, in which part program can be stored.	**4.** Same part program can be run on different machines at the same time.
5. It can't import CAD files.	**5.** System can import CAD files and convert it to part program.	**5.** The data can be processed using the MIS software so as to effectively carry out the Production planning and scheduling.
6. It can't use feedback system.	**6.** The system can use feedback system.	
7. They are not software driven.	**7.** The system is software driven.	

Lecture-6
Flexible Manufacturing System

❖ FLEXIBLE MANUFACTURING SYSTEM (FMS)

- A flexible manufacturing system (FMS) is a highly automated GT machine cell consisting of a group of processing workstations (usually CNC machine tools), interconnected by an automated material handling and storage system, and controlled by a distributed computer system.
- The reason the FMS is called flexible is that it is capable of processing a variety of different part styles simultaneously at the various workstations, and the mix of part styles and quantities of production can be adjusted in response to changing demand patterns.
- The FMS is most suited for the mid-variety, mid-volume production range.
- An FMS relies on the principles of group technology. No manufacturing system can be completely flexible. There are limits to the range of parts or products that can be made in an FMS. Accordingly, an FMS is designed to produce parts (or products) within a defined range of styles, Sizes, and processes.

❖ WHAT MAKES FMS FLEXIBLE?

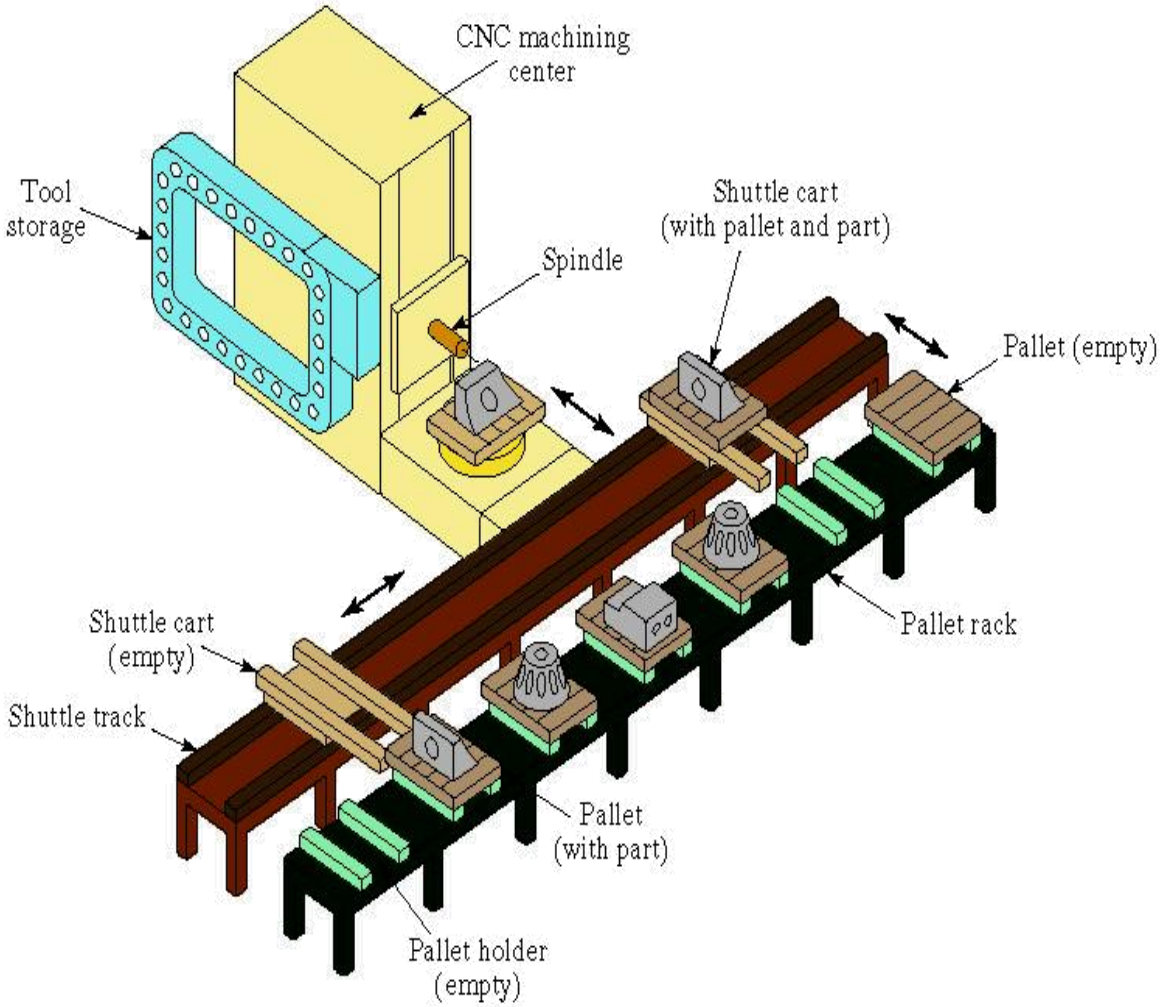
1. The ability to identify and distinguish among the different part styles processed by the system.
2. Quick changeover of operating instructions
3. Quick changeover of physical setup

❖ CLASSIFICATION OF FMS

Flexible manufacturing systems can be distinguished according to the number of machines in the system.

1. Single machine cell
2. Flexible manufacturing cell
3. Flexible manufacturing system

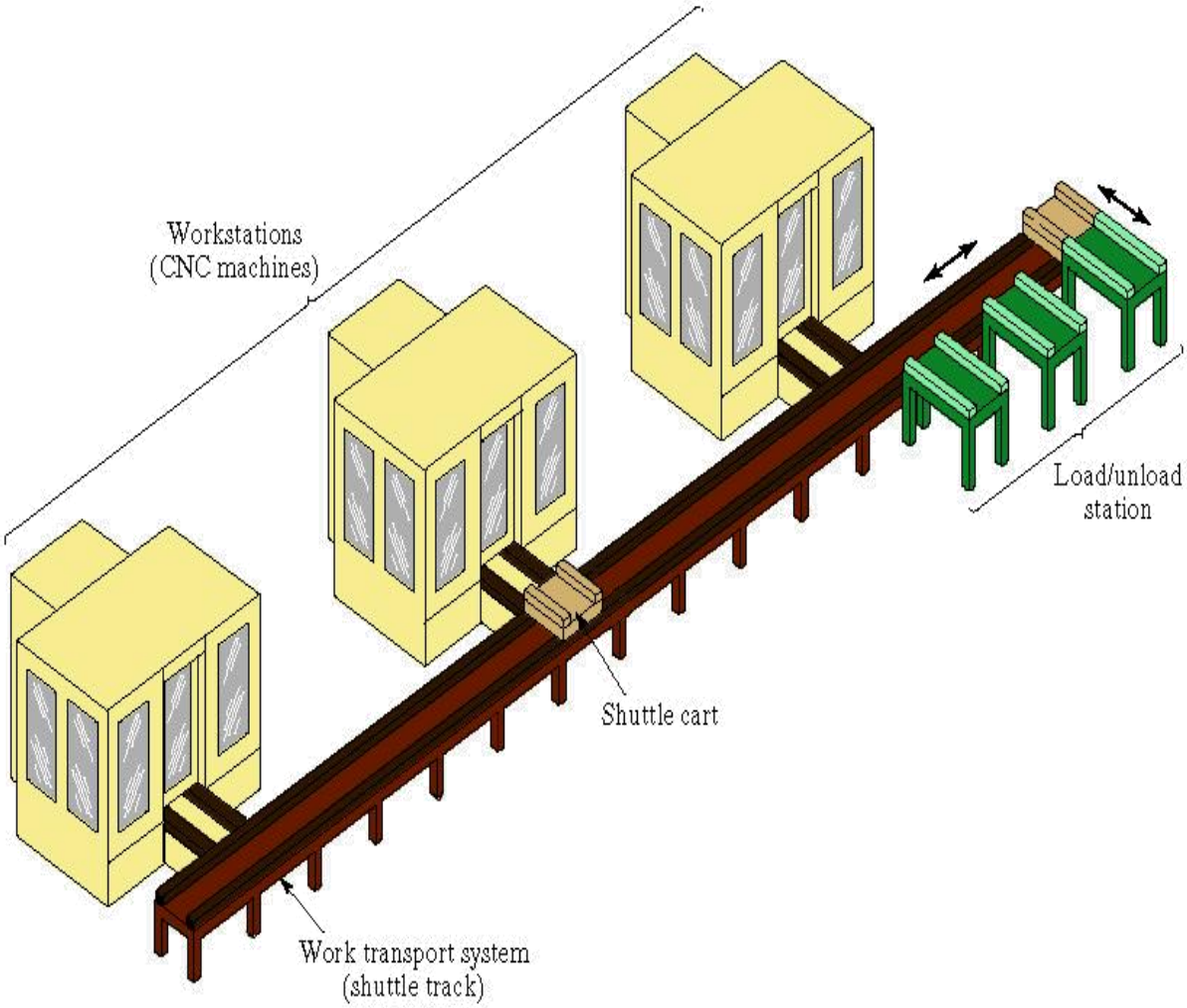
[1] Single Machine cell



- A single machine cell (SMC) consists of one CNC machining center combined with a parts storage system for unattended operation.
- Completed parts are periodically unloaded from the parts storage unit, and raw work parts are loaded into it.
- The cell can be designed to operate in either a batch mode or a flexible mode or in combinations of the two.
- When operated in a batch mode, the machine processes parts of a single style in specified lot sizes and is then changed over to process a batch of the next part style.
- When operated in a flexible mode, the system satisfies three of the four f1exibili1y tests
- It is capable of
  1. Processing different part styles,
  2. responding to changes in production schedule,
  3. Accepting new part introductions. Criterion
  4. Error recovery, cannot be satisfied because if the single machine breaks down, production stops.

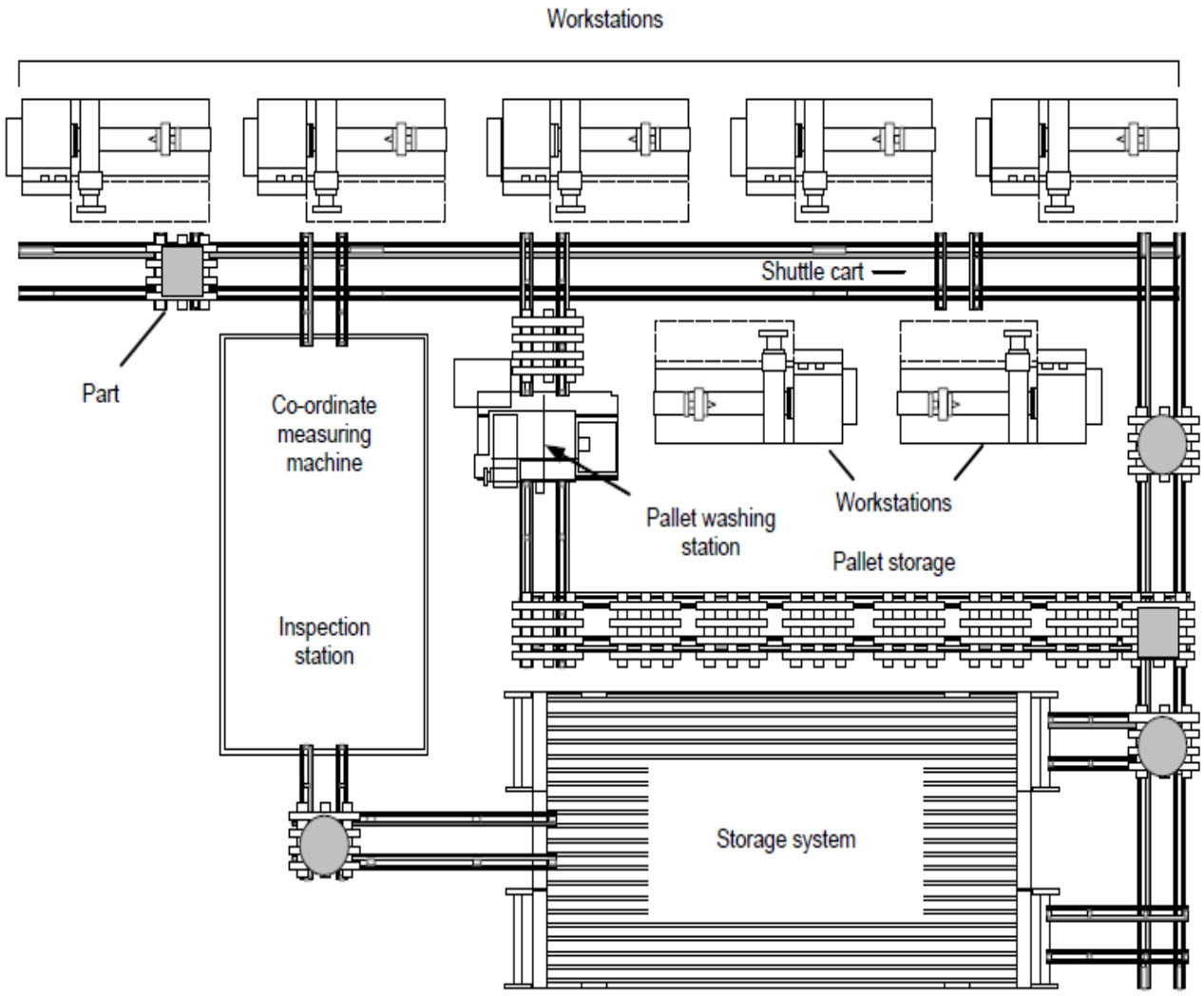
[2] Flexible Manufacturing Cell

- A flexible manufacturing all (FMC) consists of two or three processing workstations (typically CNC machining centers or turning centers) plus a part handling system.
- The part handling system is connected to a load/unload station.
- In addition, the handling system usually includes a limited parts storage capacity.
- A flexible manufacturing cell satisfies the four flexibility tests discussed previously.



[3] Flexible Manufacturing System

- A flexible manufacturing system (FMS) has four or more processing workstations connected mechanically by a common part handling system and electronically by a distributed computer system.
- FMC has two or three machines, while an FMS has four or more.
- The FMS generally includes non-processing workstations that support production but do not directly participate in it.
- The other stations include part/pallet washing stations, coordinate measuring machines.
- The computer control system of an FMS is generally larger and more sophisticated, often including functions not always found in a cell, such as diagnostics and tool monitoring.
- These additional functions are needed more in an FMS than in an FMC because the FMS is more complex.



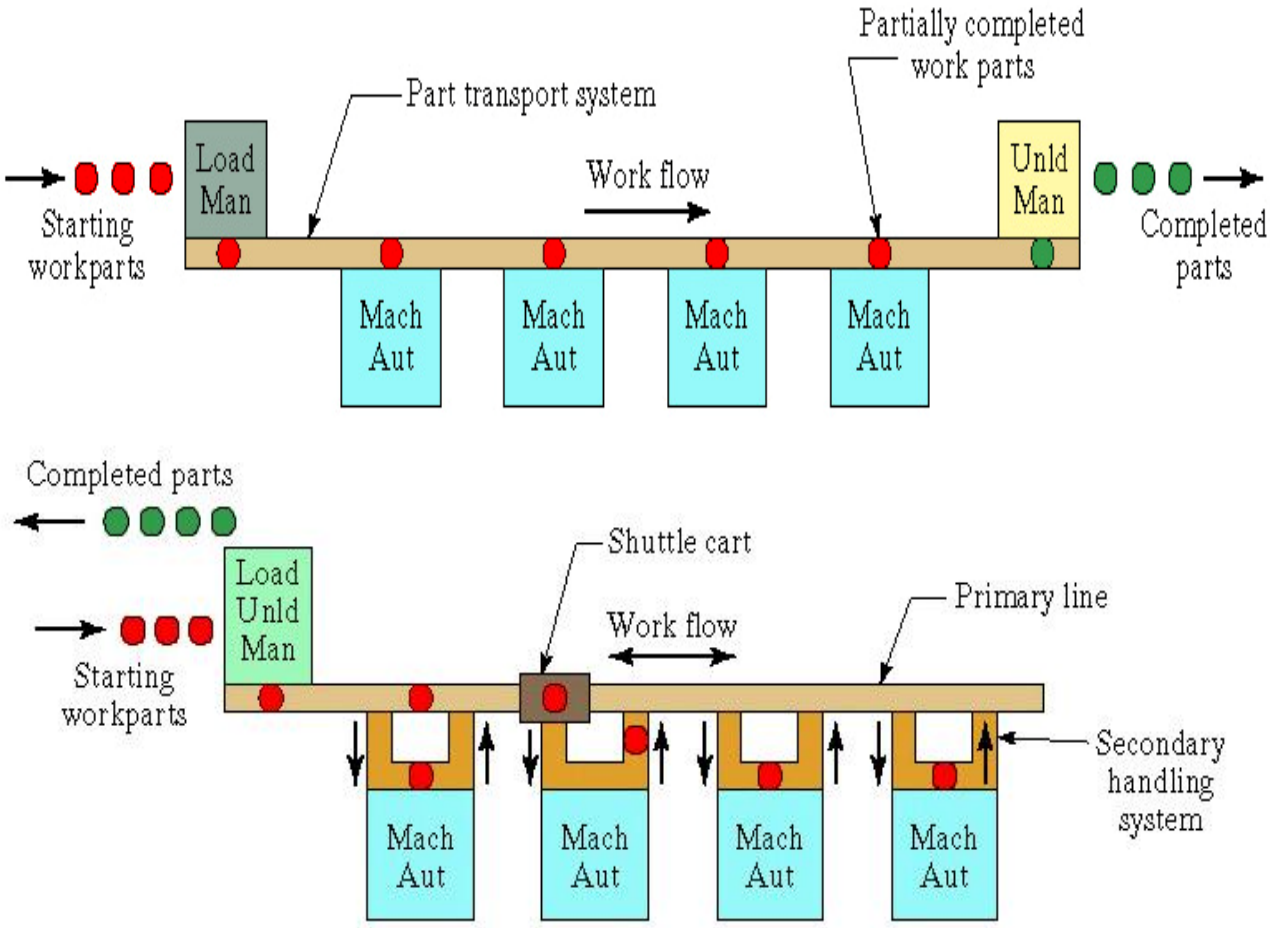
Lecture-7
FMS Layouts (part-1)

❖ FMS LAYOUTS

1. Inline FMS
2. Loop FMS
3. Ladder FMS
4. Open field FMS
5. Robot centered FMS

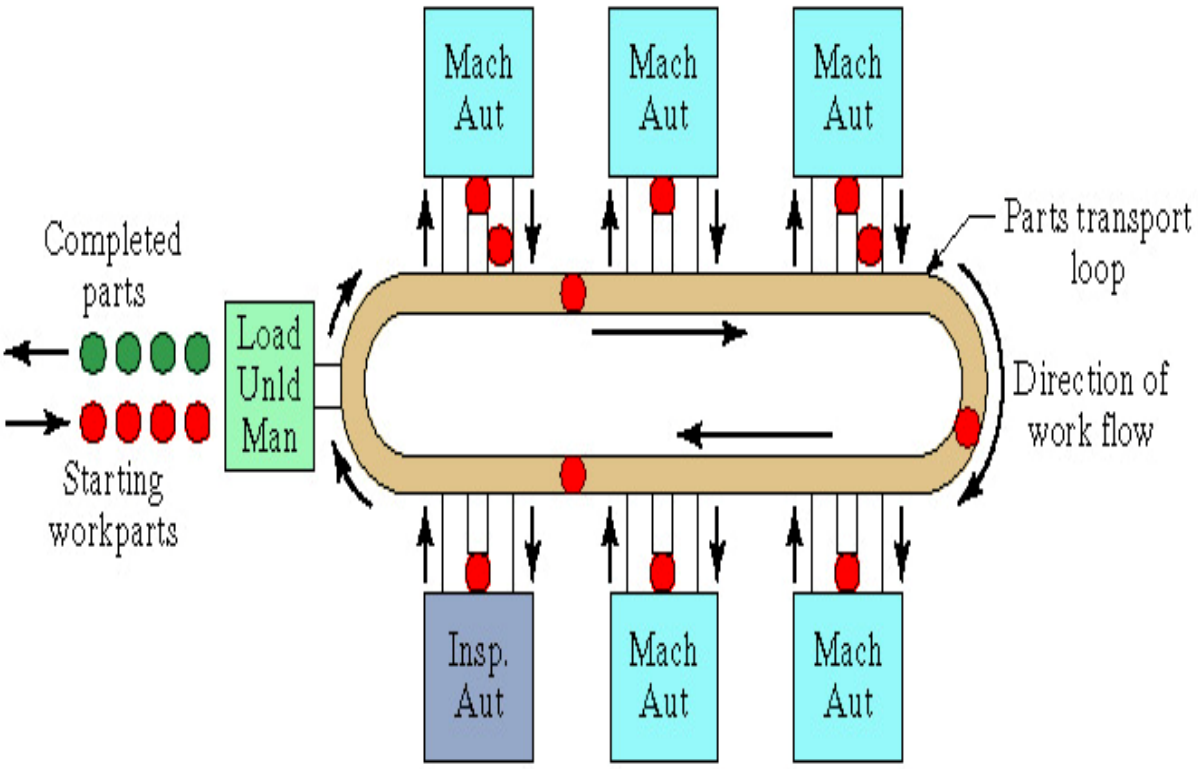
[1] Inline FMS

- The machines and handling system are arranged in a straight line.
- Parts progress from one workstation to the next in a well-defined sequence with work always moving in one direction and with no back-flow.



[2] Loop FMS

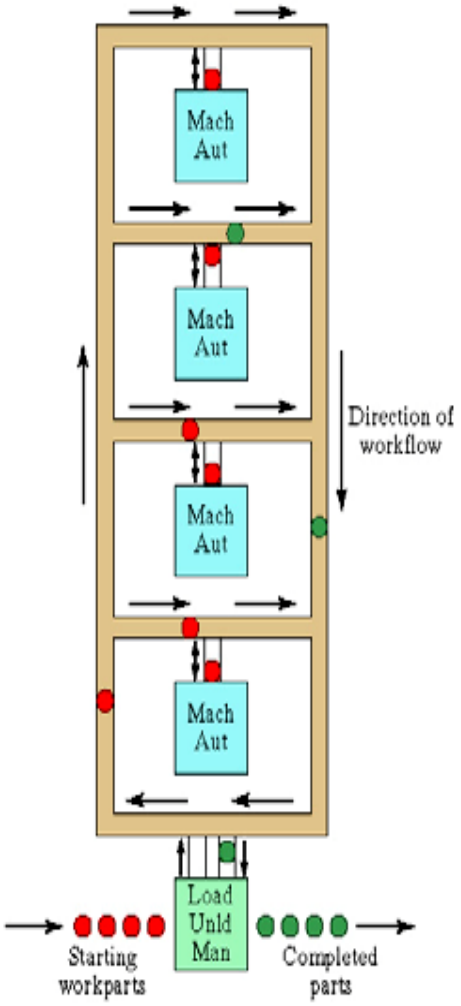
- Workstations are organized in a loop that is served by a looped parts handling system.
- Parts usually flow in one direction around the loop with the capability to stop and be transferred to any station.
- Each station has secondary handling equipment so that part can be brought-to and transferred-from the station work head to the material handling loop
- Load/unload stations are usually located at one end of the loop.



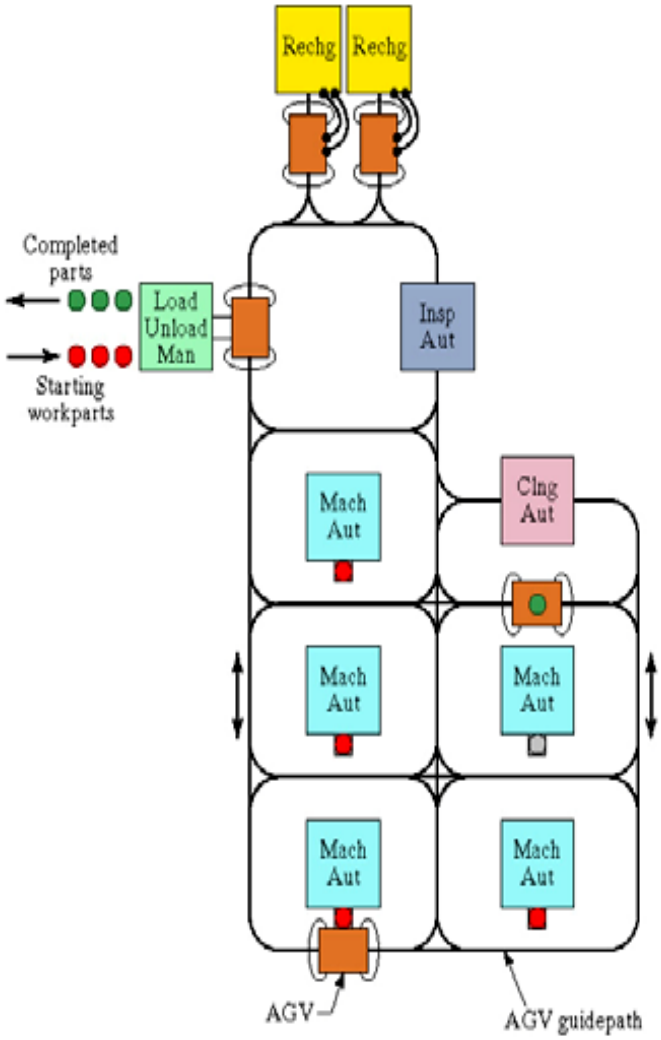
Lecture-8
FMS Layouts (part-2)

[3] Ladder FMS

- This consists of a loop with rungs upon which workstations are located.
- The rungs increase the number of possible ways of getting from one machine to the next, and remove the need for a secondary material handling system.
- It reduces average travel distance and minimizes blocking in the handling system thus reducing transport time between stations



Ladder Layout



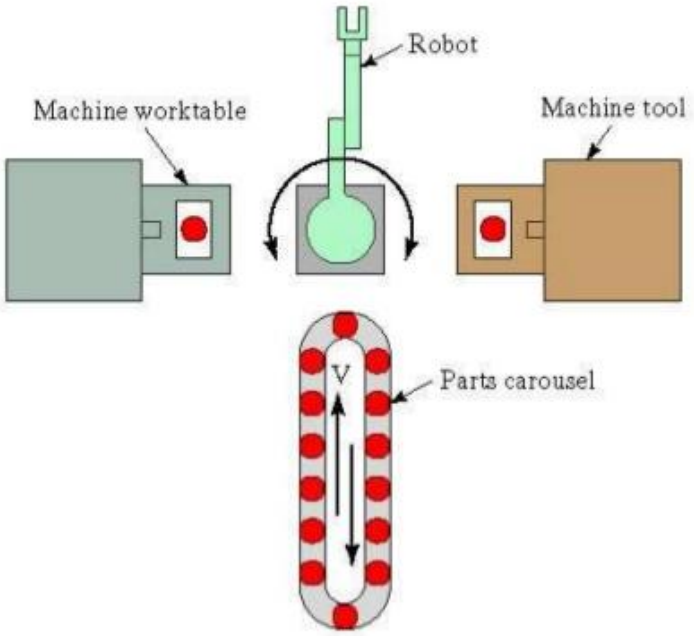
Open Field FMS

[4] Open Field FMS

- Consists of multiple loops and ladders, and may include sidings also.
- This layout is generally used to process a large family of parts,
- The number of different machine types may be limited, and parts are usually routed to different workstations depending on which one becomes available first.

[5] Robot Centered FMS

- This layout uses one or more robots as the material handling system.
- Industrial robots can be equipped with grippers that make them well suited for the handling of rotational parts, and robot-centered FMS layouts are often used to process cylindrical or disk-shaped parts



❖ ADVANTAGES OF FMS

- To reduce set up and queue times
- Improve efficiency
- Reduce time for product completion
- Utilize human workers better
- Improve product routing
- Produce a variety of Items under one roof
- Improve product quality
- Serve a variety of vendors simultaneously
- Produce more product more quickly

Lecture-9
Group Technology

❖ GROUP TECHNOLOGY

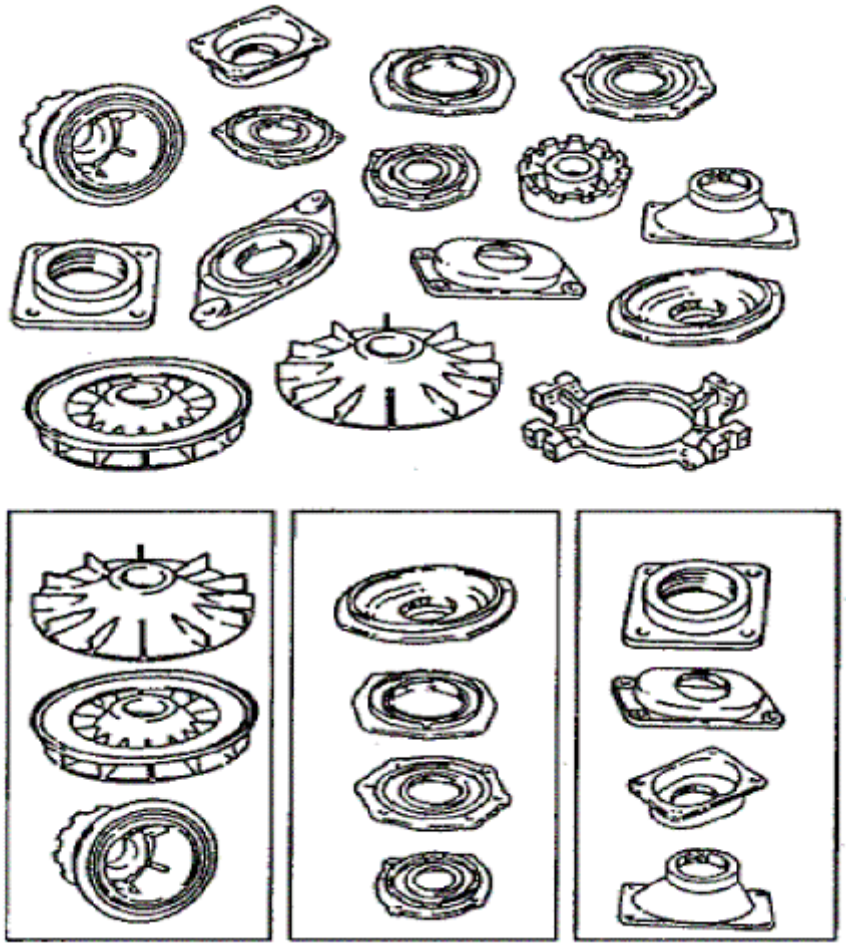
- Group technology is an approach to organizing manufacture which can be applied in any industry (machining, welding, foundry, press work, forging, plastic moulding, etc.) where small-batch variety production is used.
- Group technology is a manufacturing philosophy or principle whose basic concept is to identify and bring together related or similar parts and processes, to take advantage of the similarities which exist, during all stages of design and manufacture.
- If parts can be classified into families, and machines arranged into groups, then the handling of parts during manufacture can be easily done by robot.
- Groups of machines, chosen for each family are situated together in a group layout, in such a way that parts flow from one machine to the next in sequence of operation. It is not-necessary for every part to visit each machine, but the machines in a cell should ideally be capable of carrying out all the operations required in the family.
- Similarities among parts permit them to be classified into part families. In each part family, processing steps are similar.

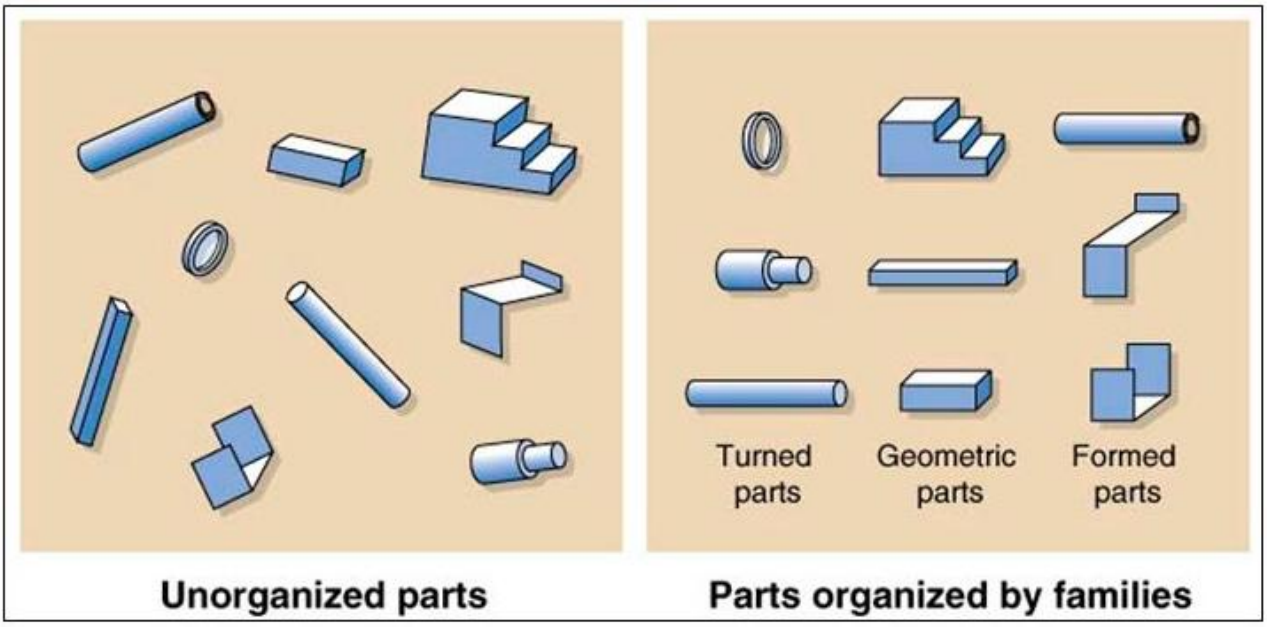
❖ PART FAMILY

- A group of parts that possess similarities in geometric shape and size, or in the processing steps used in their manufacture.
- Part families are a central feature of group technology.
- There are always differences among parts in a family but the similarities are close enough that the parts can be grouped into the same family.

❖ WAYS TO IDENTIFY PART FAMILIES

1. Visual inspection - using best judgment to group parts into appropriate families, based on the parts or photos of the parts
2. Production flow analysis - using information contained on route sheets to classify parts
3. Parts classification and coding - identifying similarities and differences among parts and relating them by means of a coding scheme




Turned parts
Geometric parts
Formed parts
Unorganized parts
Parts organized by families

Lecture-10
Group Technology Merits and Demerits

❖ **ADVANTAGES OF GROUP TECHNOLOGY:**

- Short throughput times because machines are closed together.
- Better quality because groups complete parts and the machines is closed together under one foreman.
- Lower material handling costs because machines are closed together under one foreman.
- Better accountability because of machines complete parts. The foreman can be made responsible for costs, quality, and completion by the due date.
- Training for promotion since GT provides a line of succession because a group is a mini-department.
- Automation GT is the first evolutionary step in automation.
- Reduced set up time since similar parts brought together on the same.
- Morale and job satisfaction since most workers prefer to work in groups.
- The output is improved due to improved resource utilization.
- Work in progress and finished stock levels are re-duced.
- Simplified estimating, accounting and work man-agement.
- Improved plant replacement decisions, and.
- Improved job satisfaction, morale, and communica-tion.

❖ **DISADVANTAGES OF GROUP TECHNOLOGY:**

- Additional cost of implementation of this system.
- Rate of change in product range and mix.
- Difficulties with out-of-cell operations.
- Coexistence with non-cellular systems.